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January 22, 1966 - July 22, 1966
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An Investigation of Soil Modeling Problems
Related to Impact Studies
by
William R. Cox, Associate Director

July 22, 1966

Department of Civil Engineering
The University of Texas
Austin, Texas

REVIEW OF PROGRAM

- I. GRANTS - The following is a summary of the original grant, no-cost extensions, and supplements received and requested for this program:

<u>Type</u>	<u>Period</u>	<u>Date Requested</u>	<u>Date Approved</u>
Original Grant	4-01-64 to 3-31-65	August 1963	March 26, 1964
No-cost Extension	3-31-65 to 6-01-65	November 25, 1964	February 15, 1965
Supplement No. 1 \$50,000	4-01-65 to 3-31-66	November 30, 1964	March 17, 1965
No-cost Extension	4-01-66 to 7-30-66	February 18, 1966	February 22, 1966
Supplement No. 2 \$62,000	7-30-66 to 7-31-67	February 22, 1966	--
No-cost Extension	7-31-66 to 9-30-66	July 11, 1966	July 20, 1966

- II. REPORTS - The following reports have been submitted:

<u>Report</u>	<u>Date Submitted</u>
"Static Load Versus Settlement for Geometric Shapes on Cohesionless Soil," by Raja A. Iliya and Lymon C. Reese	May 28, 1965
"A Lattice Analogy for the Solution of some Nonlinear Stress Problems," by Robert Earl Smith and Lymon C. Reese	June 29, 1965
"Behavior of a Sandy Clay Under Impact of Geometric Shapes," by Arthur R. Poor, William R. Cox and Lymon C. Reese	July 1965
"Laboratory Stress-Deformation Characteristics of Soils Under Static Loading," by Osman I. Ghazzaly and Raymond F. Dawson	May 18, 1966

The following report is receiving final editing before being submitted:

"Investigation of Field Load-Settlement Behavior of Stat-ically Loaded Model Foundation Elements in a Silty Clay," by Osman I Ghazzaly.

III. SEMI-ANNUAL STATUS REPORTS - Status reports have been submitted as follows:

<u>Period</u>	<u>Date Submitted</u>
April 1, 1964 - September 30, 1964	November 24, 1964
October 1, 1964 - March 31, 1965	March 22, 1965
July 22, 1965 - January 22, 1966	May 18, 1966*

*Report by Osman I. Ghazzaly submitted in lieu of Semi-Annual Status Report.

Fiscal Period

V. TECHNICAL PERSONNEL

Lymon C. Reese, Ph.D., Professor and Chairman of Department of Civil Engineering, The University of Texas, Project Director.

Raymond F. Dawson, M.S., Professor of Civil Engineering, The University of Texas, Project Advisor.

William R. Cox, Ph.D., Assistant Professor of Civil Engineering, The University of Texas, Associate Project Director.

Issa S. Oweis, M.S., Oklahoma State University. Mr. Oweis is preparing for admission to candidacy for a doctorate in soil mechanics. Research work for NASA will be used in his dissertation.

C. V. Girijavallabhan, M.S., University of Missouri at Rolla. Mr. Girijavallabhan is scheduled to complete his work on the doctorate in August 1966. His research work has been supported in part by NASA.

James F. Horadam, B.S., The University of Texas. Mr. Horadam expects to complete his work for the master's degree in early fall 1966. Mr. Horadam has been in direct charge of all laboratory testing on the NASA project.

Paul A. Hustad, B.S., University of Missouri at Rolla. Mr. Hustad holds a fellowship at The University of Texas. He has been appointed during the summer months to the NASA project. His master's thesis will be prepared on research work for NASA and it is expected to be completed in the fall of 1966.

TECHNICAL PROGRAMS

The following are descriptions of the studies which are being made under this grant. It is anticipated that each of these studies will be summarized in separate reports to NASA.

Resistance to Horizontal Movements of Plates, Cones and Spheres in Sand, (James F. Horadam).

Horizontal load tests have been performed on steel plates in Colorado River sand. These tests were performed in a box 3 x 3 x 6 ft in width, height, and length respectively.

The variables used in testing were the following:

- (a) two sizes of steel plates: 12 x 12 in and 12 x 18 in.
- (b) two densities of sand: dense (approximately 100 lbs per cubic foot), and
loose (approximately 90 lbs per cubic foot).
- (c) varying velocities of the horizontal thrust: 0.214 ft/sec to
0.000535 ft/sec).

The equipment used to perform this testing is summarized below.

- (1) Closed Loop Servo Loading System consisting of
 - a) 10,000 lb hydraulic actuator,
 - b) hydraulic power supply, and
 - c) console, including controls and indicator.
- (2) Recording System consisting of
 - a) recording oscillograph,
 - b) differential amplifiers, and
 - c) switch and balance unit.
- (3) Loading System

Three plates in a vertical position are positioned edge-to-edge on a rigid frame. Load is transferred to the frame from a hydraulic actuator. The three plates are each 12 in wide making the total width of the push 36 in. The height can be varied by using either 12 in or 18 in high plates. The outside two plates are mounted rigidly to a crossmember in the rigid frame. The center plate is

connected to the loading frame through load cells which are used to measure the resistance of the sand. There are four load cells on the center plate, three measuring the horizontal load and one measuring the vertical load.

Tests were run on 12 x 12 in and 12 x 18 in plates in dense and loose sand under varying velocities of load. Loading was continued until a failure plane developed in the sand ahead of the plates.

Load and deflection data were recorded on an oscillograph and data was transferred to punched cards for analysis on the CDC 1604 computer. The load per cell and total load were compiled and machine plots were made of load versus deflection.

A study will be made of the correlation between maximum total load and rate of loading.

Preparations are now underway for conducting horizontal load tests on spheres and cones. The shapes will be advanced into the sand through silhouettes cut into an end of the box containing the sand. The silhouettes will be temporarily blocked by thin plastic sheets or other suitable material.

The depth below the surface of the sand to the point of piercing of the shapes will be varied. In addition, tests will be made on loose and dense sands and at varying velocities of loading as was done with the plates.

The cones are right cones of 60 degree angles. Cones of 3.50 and 7.08 in diameter will be used. Spheres of 3.87 and 8.66 in diameter will be used. The shapes are made of aluminum.

Force-Deflection Characteristics of Dry Colorado River Sand (Paul A. Hustad).

A study is being made of the dynamic lateral force-deflection characteristics of a dry Colorado River sand as revealed in load tests on plates, cones and spheres. For the loading on plates, the sand is not allowed to move in a transverse direction, hence the problem may be considered to be of the plane strain type. Force-deflection curves have been obtained for the soil existing at its loosest state, 86 lbs per cubic foot, and at its densest state, 102.5 lbs per cubic foot.

Triaxial tests have been performed to determine the angle of internal friction of the soil. Direct shear tests were conducted to determine the angle of friction between the steel plates and the sand. Several sieve analyses were conducted to determine the gradation of the sand.

A Numerical Analysis to Determine the Force-deformation Characteristics of Soils (C. V. Girijavallabhan)

The force-deformation characteristics of sand have been determined experimentally by pushing a vertical plate into the sand. Details of experimental work are given in the previous sections.

As the above problem comes under the plane strain case, it is analyzed by using a finite element method. Computer programs have been written to solve plane strain problems, taking the non-linear behavior of the material under consideration.

The stress-strain characteristics of sand, both loose and dense, have been determined from triaxial compression tests. Solutions have been obtained for the force-deformation characteristics of the plate by making use of the stress-strain relationships in the computer program. The experimental results obtained for the force-deformation relations for a slow speed of 0.167 in/min for the plate, are compared with the computer solutions.

Stress Distributions in Soil Masses Subjected to Penetrating Bodies of Infinite Width (Issa S. Oweis).

The problem is to represent a theory for the determination of the stress distribution in a soil mass at any instant of time due to deformation caused by a penetrating body of infinite width. The problem is approached as a plane strain problem, and hence, only displacements in two directions should be specified at the boundary. When displacements are known at each point in the mass, stresses are obtained by using the proposed stress-strain relations. Distribution of stresses at the boundary is obtained in the same way. An exact solution of the equations is highly improbable and a numerical solution using a finite difference method is proposed. The solution will be programmed for a high-speed computer.